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Enumeration of the 1990 Harrison River Chinook Salmon Escapement

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by

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ABSTRACT

Farwell, M.K., N.D. Schubert and L.W. Kalnin. 1991. Enumeration of the 1990 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2111: 26 p.

In 1985, the Pacific Salmon Treaty committed the Canadian Department of Fisheries and Oceans to halt the decline in abundance of chinook salmon (**Oncorhynchus tshawytscha**) stocks. The Harrison River was designated a chinook indicator stock, and escapement has been monitored annually since 1984. In 1990, the Harrison River chinook escapement was estimated, using the Petersen mark-recapture method, at 177,375 adults. The sex composition of the escapement was 41% female and 59% male. The age composition of the recovery sample was 0.3% age 2_1, 2.3% age 3_1, 95.3% age 4_1, and 2.0% age 5_1.

Key Words: Chinook salmon, Harrison River, indicator stock, escapement, Pacific Salmon Treaty.

RÉSUMÉ

Farwell, M.K., N.D. Schubert and L.W. Kalnin. 1991. Enumeration of the 1990 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2111: 26 p.

En 1985, le Traité concernant le saumon du Pacifique a donné comme mission au ministère des Pêches et des Océans du gouvernement canadien de mettre fin à la baisse du saumon quinnat (**Oncorhynchus tshawytscha**). Le stock de la rivière Harrison a été désigné comme stock indicateur de l'état du saumon quinnat et son échappée a fait l'objet d'une surveillance annuelle depuis 1984. En 1990, l'échappée du quinnat dans la rivière Harrison a été évaluée à 177 375 adultes, selon la méthode de marquage et de recapture de Petersen. La composition de la population selon le sexe a été évaluée comme suit: 41% de femelles et 59% mâles. La composition par âge de l'échantillon de récupération était la suivante: 0,3% d'âge 2_1, 2,3% d'âge 3_1, 95,3% d'âge 4_1, et 2,0% d'âge 5_1.

Mots clés: Saumon quinnat, rivière Harrison, stock indicateur, échappée, Traité concernant le saumon du Pacifique.

INTRODUCTION

The 1985 Pacific Salmon Treaty committed management agencies in Canada and the United States of America to halt the decline in chinook salmon (**Oncorhynchus tshawytscha**) spawning escapements and to attain, by 1998, escapement goals established by each nation (Anon. 1985). To evaluate rebuilding progress, the Department of Fisheries and Oceans monitors a group of key stocks selected to represent all British Columbia chinook stocks. The status and response to management actions of these stocks is evaluated by measuring, with known precision, either annual trends in escapement (escapement indicator stocks) or in escapement and total harvest (exploitation rate indicator stocks).

Harrison River chinook was designated an escapement indicator stock in 1984 for two reasons. First, the stock comprised almost one-third of the Fraser River system chinook escapement in the 1970's (Farwell et al. 1987). The status of this stock, therefore, is an important measure of the status of the Fraser River chinook resource. Second, as a white-fleshed, fall spawning stock with juveniles which migrate to sea immediately following emergence (Fraser et al. 1982), Harrison River chinook are unique in the Fraser River system. Individual monitoring, therefore, was warranted.

Previous reports have documented the 1984-89 Harrison River chinook enumeration studies (Staley 1990, Farwell et al. 1990). The current report documents the 1990 field methods, analytic techniques and study results. Included are estimates of adult age, length, sex, adipose fin clip (AFC) incidence, coded wire tag (CWT) recoveries and escapement. The report concludes with a discussion of data limitations and recommendations for future studies.

STUDY AREA

The Harrison River is part of a complex system which drains a mountainous coastal watershed in southern British Columbia (Fig. 1). The river originates at Harrison Lake and flows southwest for 16.5 km, entering the Fraser River 116 km upstream from the Strait of Georgia. The river has an annual mean daily discharge of 449 m^3/s, with monthly mean daily maximum (947 m^3/s) and minimum (202 m^3/s) flows moderated by Lillooet and Harrison lakes.

The study area was divided into eight reaches based on homogeneity of physical characteristics (Fig. 2):

Reach 1 (Harrison Lake to km 9.5), extending from Harrison Lake downstream to Norris Creek, is characterized by a wide, low gradient channel with a depth of up to 10 m and a sandy substrate.

Reach 2 (km 9.5 to 7.7), extending to Billy Harris Slough and Reach 5 on the northwest and southeast banks, respectively, is similar to Reach 1 except water depth ranges to 3.0 m and the substrate is gravel.

Reach 3 (km 7.7 to 7.1), extending to a shear boom on the northwest bank, is characterized by a gradient higher then Reach 2 and a substrate of cobble and large gravel.

Reach 4 (km 7.1 to 6.3) includes the main channel and several side channels separated from the northwest short by gravel bars. The main channel is similar to Reach 3, with smaller substrate in the side channels.

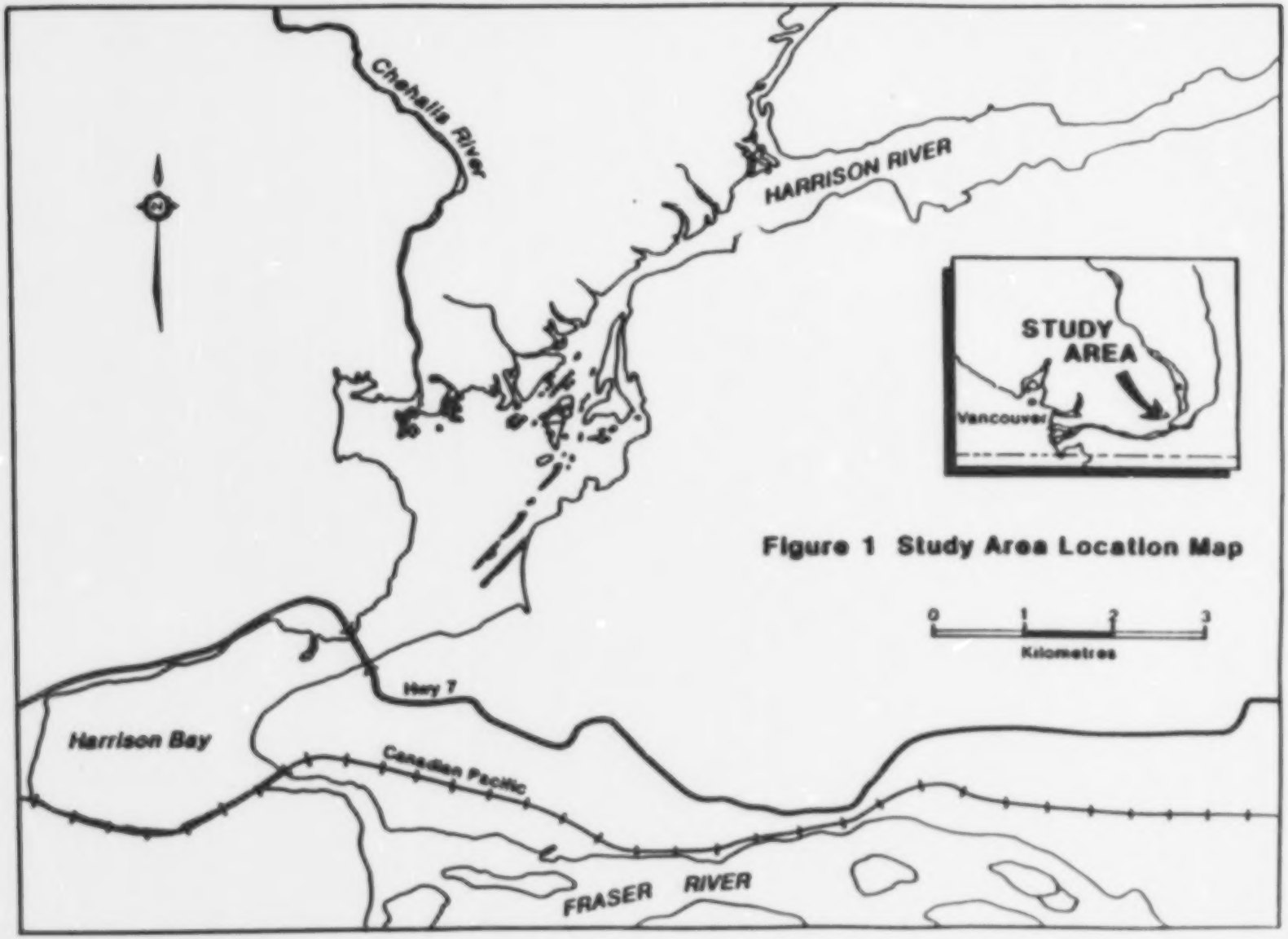

Figure 1 Study Area Location Map

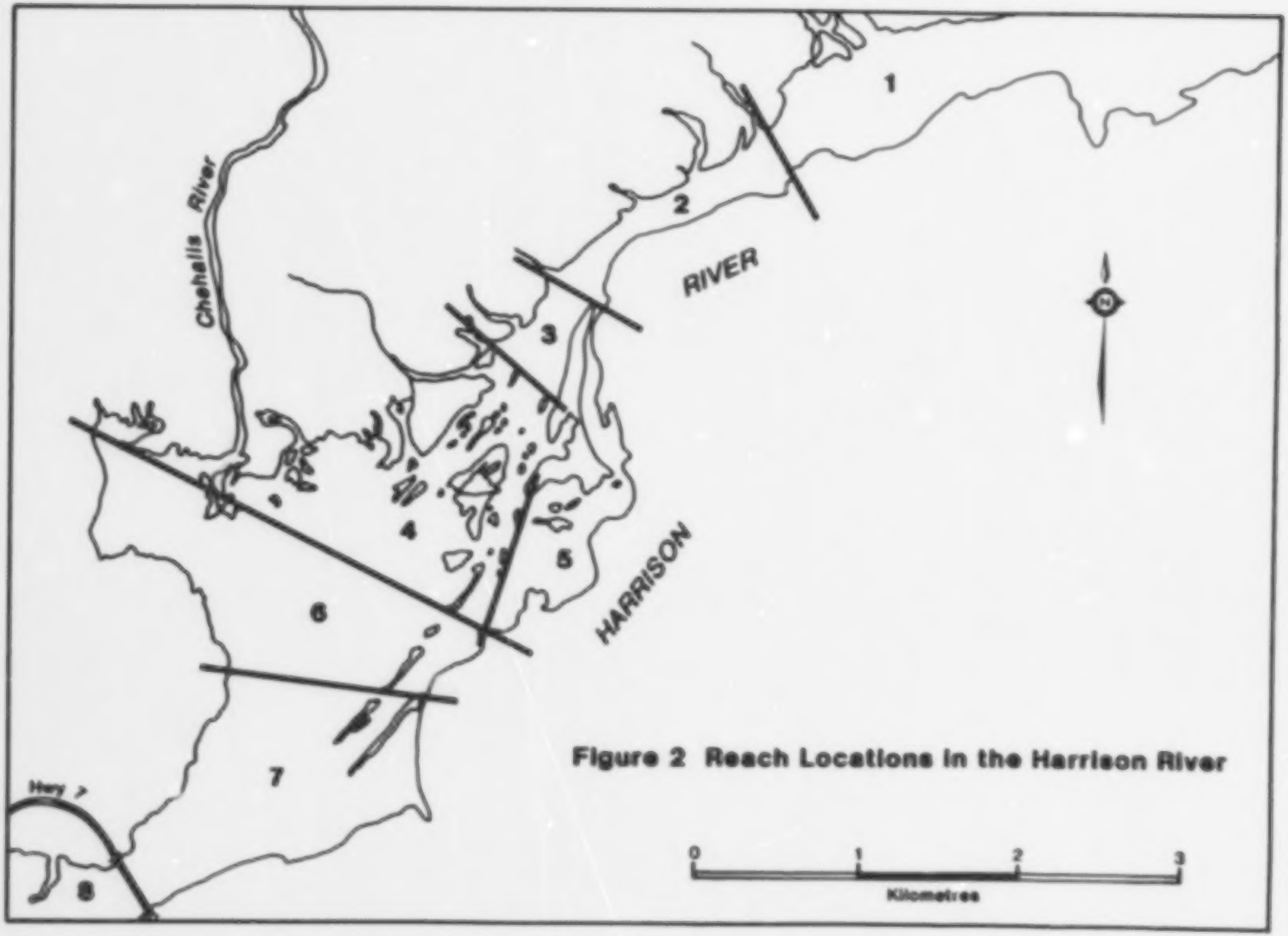

Figure 2 Reach Locations in the Harrison River

Reach 5 (km 7.7 to 6.3) is a large side channel characterized by a low gradient, a depth of up to 1.5 m, and a sand substrate. An island at the midpoint divides the reach into two sections.

Reach 6 (km 6.3 to 4.5), extending to a rock bluff on the southeast short (2 km upstream from the Highway 7 bridge), includes the main channel and part of the Chehalis River flood plain. The channel has a depth of up to 3 m and a substrate of bedrock and gravel.

Reach 7 (km 4.5 to 3.0), extending to the Highway 7 bridge, includes the main channel and part of the Chehalis River flood plain. The channel has a low gradient, a depth of up to 3 m and a mud substrate.

Reach 8 (km 3.0 to 0), which includes the main channel from the Highway 7 bridge to the Fraser River and Harrison Bay, is deep (up to 4 m) and slow, flowing over a sand and gravel substrate.

METHODS

FISH CAPTURE

Chinook adults were captured in reaches 2, 3, and 4 from October 15 to November 8, 1990 using a 67 m x 6 m x 9 cm mesh seine net. The net was set by power boat in a downstream crescent, then withdrawn from the river to enclose a small area of water along the river bank. Captured chinook were held in the net until removed for tagging and release.

TAG APPLICATION

Spaghetti tags were applied to chinook adults in a wooden tray constructed with a flexible plastic bottom and a meter stick recessed in one side. After tagging, chinook adults were released over a submerged section of the net; at no time were they removed from the water. Precocious males (jacks), defined as chinook less than 50 cm in nose-fork (NF) length, were released untagged.

The spaghetti tags consisted of a 50 cm long, 2 mm diameter hollow plastic tube numbered with a unique code. The tag was inserted with a 13 cm long stainless steel needle through the musculature and pterygiophore bones 2 cm below the anterior portion of the dorsal fin. The tag was tied tightly over the dorsal surface with a square knot.

Each tagged fish received a secondary mark to allow the assessment of tag loss. One or two 7 mm diameter holes were punched through the right operculum of males and females, respectively, using a single hole punch. Care was taken to avoid gill damage.

Date and location (reach) of capture, spaghetti tag number, sex, NF length to the nearest 0.5 cm, and adipose fin status were recorded for each chinook released with a tag. Release condition was recorded as 1 (swam away vigorously), 2 (swam away sluggishly) or 3 (required ventilation).

SPAWNING GROUND SURVEYS

Weekly spawning ground surveys were conducted from October 18 to December 14, 1990. Complete surveys were conducted weekly by two-person crews, with two to four crews required depending on carcass abundance. The shore was surveyed on foot, while deep water areas were surveyed by boat.

Carcasses were recorded by date, reach, recovery type (shore or deep

water), sex (confirmed by abdomen incision), and mark type (spaghetti tag, secondary mark or AFC). Each marked carcass and every twentieth unmarked carcass was sampled. All carcasses were cut in two with a machete and returned to the river. Sample data, recorded by date and reach, included postorbital-hypural plate (POH) length to the nearest 0.1 cm, sex, female spawning success (0%, 50%, or 100% spawned), adipose fin condition, and scales. For AFC chinook, the head was removed posterior to the eye orbit for later CWT identification. Adipose fin condition was recorded as unclipped or as complete (flush with dorsal surface), partial (nub present) or questionable (appeared clipped but fungus or decomposition obscured the area). The condition of AFC carcasses was recorded as fresh (gills red or mottled), moderately fresh (gills white, body firm), moderately rotten (body intact but soft), or rotten (skin and bones), and the absence of one or both eyes was noted.

ESCAPEMENT ESTIMATION

Total Escapement

The 1990 escapement of Harrison River chinook adults was calculated from the markrecapture data using the Petersen formula (Chapman modification) (Ricker 1975). Total escapement was the sum of escapement by sex:

1) Estimated Harrison River chinook escapement (N_t):

$$N_t = N_m + N_f$$

where:

N_m = estimated escapement of adult males;

$$= \frac{(M_m + 1)(C_m + 1)}{(R_m + 1)}$$

N_f = estimated escapement of females, analogous to above.

2) Estimated 95% confidence limits of N_t:

$$N_t \pm 1.96 \sqrt{V_t}$$

where:

N_t = total escapement estimate;

V_t = variance of the escapement estimate;

$= V_m + V_f$

V_m = variance of the adult male escapement estimate;

$$= \frac{(N_m^2)(C_m - R_m)}{(C_m + 1)(R_m + 2)}$$

N_m = adult male escapement estimate;

C_m = number of adult male carcasses examined for spaghetti tags;

R_m = number of spaghetti tagged or secondary marked adult males recovered;

V_f = variance of female escapement estimate, analogous to above.

Sex Identification Correction

The spaghetti tag application data were corrected for sex identification error. Error occurred because the development of sexually dimorphic traits was often not advanced and internal examinations could not be made. Correction of recovery data was unnecessary because all carcasses were incised and examined internally. Sex identification error was corrected as described by Staley (1990):

3) Estimated true number of males released with spaghetti tags and secondary marks (M_m):

$$M_m = \frac{M'_m - (M_t R_{m,f})/R_f}{1 - (R_{m,f}/R_f) - (R_{f,m}/R_m)}$$

where:

- M'_m = field estimate of number of males released with spaghetti tags and secondary marks;
- M_t = total number of chinook adults released with spaghetti tags and secondary marks;
- $R_{m,f}$ = number of females recovered with spaghetti tags which were released as males;
- $R_{f,m}$ = number of males recovered with spaghetti tags which were released as females;
- R_f = number of females recovered with spaghetti tags;
- R_m = number of males recovered with spaghetti tags.

4) Estimated true number of females released with spaghetti tags and secondary marks (M_f):

$$M_f = M_t - M_m$$

Adipose Fin Clipped Escapement

The estimated AFC escapement was the product of the AFC incidence in the recovery sample, the largest of the two available samples, and the mark-recapture escapement estimate. Confidence limits and escapement by CWT code were not estimated because escapement was not stratified by age.

RESULTS

MARK-RECAPTURE

Tag Application

Three thousand six hundred ten chinook adults were released with spaghetti tags and secondary marks from October 15 to November 8, 1990 (Appendix 1). Release condition was good, with only four (0.1%) requiring ventilation (Table 2). The recovery of this group (25.0%) was significantly higher ($p < 0.05$; chi-square) than that of the remaining fish (3.7%). Consequently, these fish were removed from the application and recovery samples (Table 1).

An estimated 35.7% of the males and 0.8% of the females were misidentified at the time of tagging (Appendix 2). After adjustments for release condition and sex identification error, an estimated 1,543 (42.8%) males and 2,063 (57.2%) females were released with spaghetti tags and secondary marks (Table 1).

Spawning Ground Recovery

After adjustment for release condition, 7,080 chinook adults were recovered on the spawning grounds from October 18 to December 14, 1990 (Table 1; Appendix 3). Of that total, 2,577 (36.4%) were male, 4,503 (63.6%) were female, 54 (0.8%) had AFCs, 134 (1.9%) had spaghetti tags and secondary marks, and 30 (0.4%) had secondary marks only. Males (62.2%) lost tags at a significantly higher rate than females (5.5%) ($p < 0.05$; chi-square).

SAMPLING SELECTIVITY

Period

Temporal bias in the application sample was examined by comparing

Table 1. Spaghetti tag application, carcass examination and mark recovery, by sex, of Harrison River chinook adults, 1990.

Sex	Spaghetti tags applied[a]	Carcasses examined[b]	Marks recovered[b]				
			Spaghetti tag and secondary mark	Secondary mark only	Spaghetti tag only	Total	Percent recovered
Male	1,543	2,577	14	23	0	37	2.4%
Female	2,063	4,503	120	7	0	127	6.2%
Total	3,606	7,080	134	30	0	164	4.5%

[a] Adjusted for sex identification error. Excludes 4 which required ventilation at release.
[b] Excludes 1 which required ventilation at release.

Table 2. Spaghetti tag application and recovery of Harrison River chinook salmon, by release condition, 1990.

Release condition	Spaghetti tags applied	Spaghetti tags recovered	Percent recovered
Fish swam away without assistance	3,606	134	3.7%
Fish required ventilation	4	1	25.0%
Total	3,610	135	3.7%

between periods the mark incidence in the recovery sample (Table 3), where mark incidence was defined as the incidence of chinook adults marked with either a spaghetti tag or secondary mark. Mark incidence was significantly different than expected ($p < 0.05$; chi-square), with a higher incidence (3.9%) in the week of November 19-25.

Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered (Table 4). No significant difference was noted ($p > 0.05$).

Location

Spatial bias in the application sample was examined by comparing between sections the mark incidence in the recovery sample (Table 5). Mark incidence, which ranged from 1.9% to 3.4%, was not different from that expected ($p > 0.05$; chi-square).

Recovery bias was examined by stratifying the application sample by section and comparing proportions recovered (Table 6). No significant difference was noted ($p > 0.05$).

Fish Size

Size related bias in the application sample was assessed by comparing the continuous POH length frequency distributions of marked and unmarked spawning ground recoveries. No significant difference was noted in males or females ($p > 0.05$; Kolmogorov-Smirnov two sample test).

Recovery bias was assessed by partitioning the application sample into recovered and non-recovered components and comparing the continuous MF length frequency distributions of each. No significant difference was noted in males or females ($p > 0.05$) (Table 7).

Fish Sex

Sex related bias in the application sample was assessed by comparing the sex ratio of the marked and unmarked spawning ground recoveries (Table 8). The proportion female was significantly higher in the recovered group ($p < 0.05$; chi-square).

Recovery bias was assessed by partitioning the application sample into recovered and non-recovered components and comparing the sex composition in each (Table 8). The recovery sample was biased toward females ($p < 0.05$). Furthermore, the proportion of chinook adults released with marks and recovered on the spawning grounds was significantly higher ($p < 0.05$) in females (6.2%) than males (2.4%) (Table 1).

Recovery Method

Differential behaviour related to capture and tagging stress was examined by comparing the mark incidence in carcasses recovered on the shore (2.2%) and in deep water (2.7%) (Table 9). No significant difference ($p > 0.05$; chi-square) was noted.

Spawning Success

Differential behaviour related to capture and tagging stress was examined by comparing the spawning success of marked (93.4%) and unmarked (94.4%) females (Appendix 4). No significant difference was noted ($p > 0.05$; chi-square).

ESTIMATION OF SPAWNER POPULATION

Total Escapement

The 1990 escapement of Harrison River chinook adults, calculated from

Table 3. Incidence of spaghetti tags or secondary marks in chinook salmon recovered on the spawning grounds, by period, in the Harrison River, 1990.

Recovery period	Recovered with spaghetti tag or secondary mark		Total recovery		Mark incidence (%)
	Number	Percent	Number	Percent	
22 Oct to 28 Oct	6	3.6%	445	6.3%	1.3%
29 Oct to 04 Nov	19	11.5%	1,104	15.6%	1.7%
05 Nov to 11 Nov	34	20.6%	1,819	25.7%	1.9%
12 Nov to 18 Nov a	0	0.0%	0	0.0%	-
19 Nov to 25 Nov	53	32.1%	1,366	19.3%	3.9%
26 Nov to 02 Dec	22	13.3%	845	11.9%	2.6%
03 Dec to 09 Dec	15	9.1%	633	8.9%	2.4%
10 Dec to 16 Dec	16	9.7%	869	12.3%	1.8%
Total	165	-	7,081	-	2.3%

a. Flood conditions, no recovery effort.

Table 4. Proportion of the spaghetti tag application sample recovered on the spawning grounds, by period, in the Harrison River, 1990.

Application period	Spaghetti tags applied[a]	Spaghetti tags recovered[b]	Percent recovered
15 Oct to 21 Oct	816	33	4.0%
22 Oct to 28 Oct	1,081	39	3.6%
29 Oct to 04 Nov	1,066	43	4.0%
05 Nov to 11 Nov	643	19	3.0%
Total	3,606	134	3.7%

[a] Excludes 4 which required ventilation at release.
[b] Excludes 1 which required ventilation at release, and 30 with a secondary mark only.

Table 5. Incidence of spaghetti tags and secondary marks, by reach and section, in the Harrison River spawning ground recovery sample, 1990.

Section	Reach	Carcasses examined		Carcasses recovered with spaghetti tags or secondary marks[a]		Mark incidence (%)
		Number	Percent	Number	Percent	
Upper	Reach 1	0	0.0%	0	0.0%	-
	Reach 2	155	2.2%	4	2.4%	2.6%
	Total	155	2.2%	4	2.4%	2.6%
Middle	Reach 3	638	9.0%	15	9.1%	2.4%
	Reach 4	1,933	27.3%	41	25.0%	2.1%
	Reach 5	553	7.8%	19	11.6%	3.4%
	Total	3,124	44.1%	75	45.7%	2.4%
Lower	Reach 6	2,250	31.8%	42	25.6%	1.9%
	Reach 7	1,032	14.6%	29	17.7%	2.8%
	Reach 8	519	7.3%	14	8.5%	2.7%
	Total	3,801	53.7%	85	51.8%	2.2%
Total	-	7,080	-	164	-	2.3%

[a] Excludes 1 which required ventilation at release.

Table 6. Proportion of the spaghetti tag application sample recovered on the spawning grounds, by application reach, in the Harrison River, 1990.

Reach	Tags applied[a]	Tags recovered[b]	Percent recovered
Reach 2	3,542	134	3.8%
Reach 3	42	0	0.0%
Reach 4	22	0	0.0%
Total	3,606	134	3.7%

[a] Excludes 4 which required ventilation at release.
[b] Excludes 1 which required ventilation at release and 30 with a secondary mark only.

Table 7. Spaghetti tag application and recovery of Harrison River chinook adults, by nose-fork length, 1990.

Nose-fork length (cm)	Spaghetti tags applied[a]	Carcasses recovered with spaghetti tags[b]	Percent recovered
60-69	80	1	1.3%
70-79	268	6	2.2%
80-89	1,553	65	4.2%
90-99	1,403	54	3.9%
100-109	287	8	2.8%
110-119	15	0	0.0%
Total	3,606	134	3.7%

[a] Excludes 4 which required ventilation at release.
[b] Excludes 1 which required ventilation at release and 30 with a secondary mark only.

Table 8. Sex composition of application and recovery samples of Harrison River chinook adults, 1990.

		Application sample[a]			Recovery sample[b]		
Sex		Recovered[b]	Not recovered	Total	Marked	Unmarked	Total
Male	Percent	22.6	38.3	37.5	22.6	36.7	36.4
	Number	37	1,317	1,354	37	2,540	2,577
Female	Percent	77.4	61.7	62.5	77.4	63.3	63.6
	Number	127	2,125	2,252	127	4,376	4,503
Total	Number	164	3,442	3,606	164	6,916	7,080

[a] Excludes 4 which required ventilation at release.
[b] Excludes 1 which required ventilation at release.

Table 9. Incidence of spaghetti tags and secondary marks in chinook carcasses recovered on the spawning grounds, by recovery method, in the Harrison River, 1990.

Method	Number recovered[a]	Recovered with tags or secondary marks[a]	Mark incidence (%)
Shore recovery	5,588	124	2.2%
Deep water recovery	1,492	40	2.7%
Total	7,080	164	2.3%

[a] Excludes 1 which required ventilation at release.

Table 10. Escapement estimates, by sex, for Harrison River chinook adults, 1990.

Sex	Escapement estimate	95% confidence limit	
		Lower	Upper
Male	104,748	72,116	137,380
Female	72,627	60,273	84,981
Total	177,375	142,483	212,268
AFC Adult	1,353	-	-

the mark-recapture data, was 177,375, with lower and upper 95% confidence limits of 142,483 and 212,268 (Table 10). The escapement of male and female chinook adults was 104,748 and 72,627, respectively.

Adipose Fin Clipped Escapement

Based on the chinook adult AFC incidence in the recovery sample (0.8%) (Appendix 3), the 1990 escapement of AFC adults was 1353 chinook (Table 10). CWT escapement estimates were not determined because total escapement was not stratified by age; however, recoveries are summarized by CWT code and sex in Appendix 5. CWT loss was not influenced by carcass decomposition or predators ($p > 0.05$; chi square); however, the CWT absence (100%) in carcasses with questionable clips was significantly higher than that in carcasses with complete (13%) or partial clips (50%) ($p < 0.05$) (Appendix 6).

AGE, LENGTH AND SEX

The age composition of 299 chinook adults recovered without AFCs was 2.0% age 3_1, 96.3% age 4_1 and 1.7% age 5_1 (Table 11). The age composition of 45 carcasses with AFCs was 2.2% age 2_1, 4.4% age 3_1, 88.9% age 4_1 and 4.4% age 5_1 (Table 11). No errors were noted in the aging of chinook with CWT's.

Mean NF length of males and females in the application sample was 90.9 cm and 87.7 cm, respectively (Appendix 7). Mean POH lengths of males and females in the recovery sample were 73.5 cm and 72.0 cm, respectively (Appendix 7).

Females comprised 62.5% of the application sample, 63.6% of the recovery sample (Table 8) and 40.9% of the population estimate.

DISCUSSION

ADULT CAPTURE TECHNIQUE

A basic assumption underlying Petersen mark-recapture studies is that capture and tagging do not influence the subsequent catchability of the fish. We evaluated this factor in two ways. First, we compared the mark incidence in carcasses recovered on the shore and in deep water main channel areas. We assumed that stressed fish would move passively downstream, with the most stressed individuals dying and being differentially recovered in main channel areas. Because no difference was noted, and because mark incidence was not high in the lower reaches, we believe differential loss of marked fish was minor. Second, we compared the spawning success in spaghetti tagged and untagged females. Because there was no significant difference in spawning success, we concluded that capture and marking did not influence subsequent behaviour.

SAMPLING SELECTIVITY

A second assumption underlying Petersen mark-recapture studies is that the population is sampled in a random or representative manner (Ricker 1975). In studies when non-representative sampling occurs, accurate results may still be achieved if one sample is representative (Robson 1969). In the present study, it was not possible to test for representativeness because the true population parameters were not known. Instead, we examined the samples for four biases, temporal, spatial, fish size and fish sex, as indicators of weaknesses in the study design. Biases were identified in both the tag application (temporal bias and bias to females) and recovery (bias to females) samples (Table 12).

Table 11. Age composition of chinook carcasses recovered on the spawning grounds, by adipose fin and CWT status, in the Harrison River, 1990.

Age	Adipose fin present		Adipose fin absent		Coded wire tag present	
	no.	%	no.	%	no.	%
2_1	0	0.0%	1	2.2%	1	2.9%
3_1	6	2.0%	2	4.4%	2	5.7%
4_1	288	96.3%	40	88.9%	30	85.7%
5_1	5	1.7%	2	4.4%	2	5.7%
Total	299	-	45	-	35	-

Table 12. Summary of results of statistical tests for bias in the 1990 Harrison River escapement estimation study.

Test	Application sample	Recovery sample
Period	Bias to 19 Nov to 25 Nov	No bias
Location	No bias	No bias
Fish size	No bias	No bias
Fish sex	Bias toward females	Bias toward females
Recovery method	-	No bias

Neither bias, however, was likely to have introduced bias in the escapement estimate. The temporal bias, while present in the application sample, was not noted in the recovery sample. The sex bias was corrected analytically by calculating escapement by sex. We concluded, therefore, that sampling selectivity was unlikely to have introduced significant bias in the 1990 Harrison River chinook escapement estimate.

ESCAPEMENT TRENDS

The Harrison River mark-recapture study was implemented in 1984 to monitor the rebuilding expected from management actions implemented after the signing of the Pacific Salmon Treaty. From 1984 to 1988, Harrison chinook escapements showed a strong negative trend. Escapement peaked at 174,800 in 1985 and declined for three successive years to 35,100 in 1988 (Staley 1990). Escapement increased to 74,685 in 1989 (Farwell et al 1990). The 1990 escapement estimate of 177,375 is the highest since this mark-recapture study was implemented; however, the stock is still below the 1998 escapement goal of 241,700.

SUMMARY

1. The Harrison River chinook stock is one of a group of British Columbia chinook stocks being monitored to evaluate escapement responses to management actions implemented under the Pacific Salmon Treaty.

2. Adult spawners were enumerated by a mark-recapture study from October 15 to December 14, 1990. Chinook adults were captured using a beach seine and marked with spaghetti tags and opercular punches. The escapement was censused by the recovery of carcasses following spawning.

3. The 1990 chinook adult escapement was estimated from a spaghetti tag application sample of 3,606, a recovery sample of 7,080, and a recovery of 164 carcasses with spaghetti tags or secondary marks. The estimated escapement was 177,375 chinook adults, of which 72,627 were female and 104,748 were male, and 1,353 had adipose fin clips.

4. The age composition, measured from the recovery sample, was:

	2_1	3_1	4_1	5_1
Female	0%	2%	96%	2%
Male	1%	4%	93%	2%

POH length averaged 72.0 cm for females and 73.5 for males.

5. Biases were identified in both the application and recovery samples; however, there was no indication that the 1990 escapement estimate was biased.

ACKNOWLEDGEMENTS

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APPENDICES

Appendix 1. Chinook adult spaghetti tag application, by adipose fin status and sex, in the Harrison River, 1990. a

Date	Beach	Adipose present			Adipose absent			Total		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
15-Oct	2	43 b	64	107	0	0	0	43	64	107
16-Oct	2	76	70	146	2	1	3	76	71	147
17-Oct	2	43	84	127	1	0	1	44	84	128
18-Oct	2	51	129	180	1	3	4	52	132	184
19-Oct	2	109	140	249	1	1	2	110	141	251
22-Oct	2	104	145 c	249	1	0	1	105	145	250
23-Oct	2	99	139	238	1	3	4	100	142	242
24-Oct	2	27	105	132	2	0	2	29	105	134
	4	12	9	21	0	1	1	12	10	22
25-Oct	2	126	170	296	0	4	4	126	174	300
26-Oct	2	37	57	94	0	0	0	37	57	94
	3	24	18	42	0	0	0	24	18	42
29-Oct	2	83	194	277	0	0	0	83	194	277
30-Oct	2	101	198	299	0	1	1	101	199	300
31-Oct	2	68	143	211	0	2	2	68	145	213
01-Nov	2	100	173	273	2	1	3	102	174	276
05-Nov	2	76	136	212	0	1	1	76	137	213
06-Nov	2	91	130	221	1	0	1	92	130	222
08-Nov	2	75	131	206	0	2	2	75	133	208
Total	2	1,307	2,208	3,515	12	19	31	1,319	2,227	3,546
	3	24	18	42	0	0	0	24	18	42
	4	12	9	21	0	1	1	12	10	22
Total	-	1,343	2,235	3,578	12	20	32	1,355	2,255	3,610

a. Not corrected for sex identification errors.
b. One required ventilation.
c. Three required ventilation.

Appendix 2. Spaghetti tag recoveries in the Harrison River, by application and recovery date and location, 1990.

Application sample					Recovery sample				
Date	Reach	NF length (cm)	Sex	Adipose fin	Date	Reach	POH length (cm)	Sex	Days out
15-Oct	2	97.0	F	P	05-Nov	5	76.4	F	21
15-Oct	2	90.0	F	P	25-Oct	4	72.3	F a	10
15-Oct	2	88.0	F	P	06-Nov	7	70.1	F	22
15-Oct	2	100.0	F	P	01-Nov	3	81.4	F	17
15-Oct	2	88.0	F	P	27-Nov	4	66.4	F	43
15-Oct	2	83.0	F	P	25-Oct	2	66.3	F	10
16-Oct	2	91.0	F	P	07-Nov	3	73.5	F	22
16-Oct	2	96.0	F	P	08-Nov	4	77.0	F	23
16-Oct	2	87.5	F	P	28-Nov	4	68.6	F	43
16-Oct	2	89.0	F	P	01-Nov	3	71.7	F	16
16-Oct	2	97.0	F	P	08-Nov	4	80.5	F	23
16-Oct	2	91.0	F	P	02-Nov	5	77.0	F	17
16-Oct	2	87.0	F	P	11-Dec	5	65.3	F	56
17-Oct	2	82.0	F	P	29-Nov	5	59.7	F	43
17-Oct	2	89.0	F	P	05-Nov	6	70.2	F	19
17-Oct	2	82.0	F	P	07-Nov	4	69.0	F	21
18-Oct	2	89.0	F	P	07-Nov	3	71.0	F	20
18-Oct	2	97.5	F	P	05-Nov	6	78.8	F	18
18-Oct	2	86.0	F	P	25-Oct	5	69.5	F	7
18-Oct	2	92.0	F	P	02-Nov	6	75.2	F	15
18-Oct	2	84.0	F	P	04-Dec	4	67.8	F	47
18-Oct	2	98.0	F	P	06-Nov	7	81.5	F	19
18-Oct	2	94.0	F	P	05-Nov	6	75.1	F	18
19-Oct	2	83.0	F	P	08-Nov	4	68.1	F	20
19-Oct	2	84.0	F	P	19-Nov	8	69.0	M	31
19-Oct	2	84.0	F	P	07-Nov	3	68.8	F	19
19-Oct	2	86.0	F	P	26-Oct	6	69.0	F	7
19-Oct	2	94.5	F	P	30-Oct	5	75.4	F a	11
19-Oct	2	84.0	M	P	01-Nov	5	71.4	F	13
19-Oct	2	91.0	F	P	20-Nov	7	72.8	F	32
19-Oct	2	93.0	F	P	30-Oct	4	75.2	F	11
19-Oct	2	92.0	F	P	01-Nov	3	76.1	F	13
19-Oct	2	78.0	F	P	05-Nov	6	65.6	F a	17
22-Oct	2	90.0	F	P	04-Dec	4	71.1	F	43
22-Oct	2	96.0	F	P	06-Nov	7	78.8	F b	15
22-Oct	2	85.0	F	P	25-Oct	2	69.6	F	3
22-Oct	2	80.0	F	P	05-Nov	6	66.4	F a	14
22-Oct	2	90.0	F	P	20-Nov	7	73.2	F	29
22-Oct	2	78.5	F	P	20-Nov	7	60.5	F	29
22-Oct	2	96.0	F	P	02-Nov	7	78.5	F	11
22-Oct	2	100.0	M	P	23-Oct	7	78.6	M	1
22-Oct	2	89.0	F	P	01-Nov	5	72.3	F	10
23-Oct	2	92.0	F	P	06-Nov	7	73.0	F	14
23-Oct	2	83.0	F	P	01-Nov	3	67.7	F	9
23-Oct	2	84.5	F	P	06-Nov	7	68.8	F	14
23-Oct	2	87.0	F	P	21-Nov	6	72.4	F	29
23-Oct	2	84.0	F	P	07-Nov	5	68.0	F	15

Appendix 2. Spaghetti tag recoveries in the Harrison River, by application and recovery date and location, 1990.

Application sample					Recovery sample				
Date	Reach	MF length (cm)	Sex	Adipose fin	Date	Reach	POH length (cm)	Sex	Days out
23-Oct	2	81.0	F	P	02-Nov	5	66.8	F	10
23-Oct	2	98.0	F	P	07-Nov	3	79.7	F	15
23-Oct	2	78.0	F	P	06-Nov	7	64.9	F	14
23-Oct	2	87.0	F	P	29-Nov	4	68.2	F	37
24-Oct	2	81.0	F	P	22-Nov	5	65.5	F	29
24-Oct	2	83.0	F	P	02-Nov	6	68.0	F	9
24-Oct	2	91.0	F	P	03-Dec	4	72.3	F	40
24-Oct	2	95.0	F	P	07-Nov	3	77.0	F	14
24-Oct	2	88.0	F	P	07-Nov	3	71.0	F	14
24-Oct	2	87.0	F	P	05-Dec	6	69.5	F	42
24-Oct	2	103.0	F	P	06-Nov	7	84.0	F	13
24-Oct	2	92.0	F	P	29-Nov	5	74.7	F	36
25-Oct	2	88.0	M	P	20-Nov	7	74.5	M	26
25-Oct	2	87.0	F	P	11-Dec	4	68.1	F	47
25-Oct	2	87.0	F	P	13-Dec	5	70.4	F	49
25-Oct	2	90.0	F	P	30-Nov	7	72.8	F	36
25-Oct	2	88.0	F	P	19-Nov	8	71.0	F	25
25-Oct	2	92.5	F	P	02-Nov	6	73.5	F	8
25-Oct	2	84.0	F	P	22-Nov	5	66.5	F	28
25-Oct	2	96.2	F	P	20-Nov	7	76.0	F	26
25-Oct	2	61.0	M	P	02-Nov	5	47.0	M	8
25-Oct	2	94.5	F	P	28-Nov	4	75.1	F	34
26-Oct	2	79.0	F	P	21-Nov	6	65.1	F	26
26-Oct	2	92.0	F	P	05-Nov	6	75.3	F	10
26-Oct	2	102.0	M	P	28-Nov	4	75.4	M	33
26-Oct	2	92.5	F	P	19-Nov	8	75.0	F	24
29-Oct	2	86.5	F	P	22-Nov	6	69.5	F	24
29-Oct	2	88.0	F	P	03-Dec	6	72.0	F	35
29-Oct	2	82.0	F	P	04-Dec	4	61.6	F	36
29-Oct	2	97.0	F	P	20-Nov	7	77.6	F	22
29-Oct	2	82.0	F	P	22-Nov	6	65.1	F	24
29-Oct	2	87.0	F	P	11-Dec	4	68.4	F	43
29-Oct	2	93.0	F	P	21-Nov	5	77.8	F	23
29-Oct	2	97.0	F	P	19-Nov	8	80.2	F	21
29-Oct	2	88.0	F	P	20-Nov	5	72.5	F	22
29-Oct	2	89.0	F	P	03-Dec	5	68.7	F	35
29-Oct	2	81.0	F	P	05-Nov	6	65.2	F	7
29-Oct	2	89.0	F	P	22-Nov	4	59.9	F	24
30-Oct	2	87.0	F	P	12-Dec	4	71.8	F	43
30-Oct	2	94.0	M	P	05-Nov	6	73.7	M	6
30-Oct	2	89.0	F	P	28-Nov	4	76.8	M	29
30-Oct	2	84.0	F	P	03-Dec	6	69.5	F	34
30-Oct	2	84.0	F	P	29-Nov	4	65.2	F	30
30-Oct	2	96.0	F	P	22-Nov	4	75.0	F	23
30-Oct	2	91.0	F	P	20-Nov	5	74.5	F	21
30-Oct	2	85.0	F	P	22-Nov	6	69.2	F	23
30-Oct	2	91.0	F	P	21-Nov	6	74.5	F	22

Appendix 2. Spaghetti tag recoveries in the Harrison River, by application and recovery date and location, 1990.

Application sample					Recovery sample				
Date	Reach	AF length (cm)	Sex	Adipose fin	Date	Reach	POH length (cm)	Sex	Days out
31-Oct	2	90.0	F	P	19-Nov	8	71.0	M	19
31-Oct	2	89.0	F	P	04-Dec	4	70.4	M	34
31-Oct	2	85.0	F	P	11-Dec	4	67.6	F	41
31-Oct	2	87.0	F	P	22-Nov	5	70.1	F	22
31-Oct	2	87.0	F	P	19-Nov	8	68.5	F	19
31-Oct	2	93.0	F	P	02-Nov	5	76.5	F	2
01-Nov	2	95.5	F	P	22-Nov	4	71.5	F	21
01-Nov	2	79.0	F	P	22-Nov	5	64.0	F	21
01-Nov	2	87.0	F	P	21-Nov	6	69.9	F	20
01-Nov	2	82.0	F	P	29-Nov	5	66.5	F	28
01-Nov	2	87.0	M	P	22-Nov	6	68.8	M	21
01-Nov	2	92.0	F	P	07-Nov	3	75.1	F	6
01-Nov	2	93.0	F	P	29-Nov	4	77.5	F	28
01-Nov	2	78.0	F	P	07-Nov	3	65.7	F	6
01-Nov	2	90.0	F	P	20-Nov	7	74.0	F	19
01-Nov	2	94.0	F	P	07-Nov	3	78.4	F	6
01-Nov	2	88.0	F	P	20-Nov	7	72.0	F	19
01-Nov	2	82.0	F	P	19-Nov	8	67.5	F	18
01-Nov	2	89.5	F	P	06-Nov	7	73.5	F	5
01-Nov	2	82.0	F	P	22-Nov	6	69.6	F	21
01-Nov	2	100.0	F	P	20-Nov	7	79.5	F	19
01-Nov	2	84.0	F	P	03-Dec	6	67.6	F	32
05-Nov	2	89.0	F	P	19-Nov	8	73.6	F	14
05-Nov	2	103.0	M	P	14-Dec	8	83.3	M	39
05-Nov	2	95.0	F	P	11-Dec	4	73.6	F	a 36
05-Nov	2	98.0	F	P	22-Nov	4	77.2	F	a 17
06-Nov	2	82.0	F	P	22-Nov	4	65.5	F	16
06-Nov	2	94.0	F	P	29-Nov	5	75.5	F	23
06-Nov	2	101.0	F	P	11-Dec	4	78.8	F	35
06-Nov	2	85.0	F	P	29-Nov	5	67.3	F	23
06-Nov	2	90.5	F	P	03-Dec	6	71.5	F	27
06-Nov	2	92.0	F	P	08-Nov	4	79.8	M	2
08-Nov	2	96.0	M	P	30-Nov	8	75.9	M	22
08-Nov	2	92.5	F	P	21-Nov	6	75.0	F	13
08-Nov	2	88.0	F	P	13-Dec	4	72.2	F	35
08-Nov	2	103.0	M	P	14-Dec	8	81.2	M	36
08-Nov	2	85.0	F	P	30-Nov	7	69.5	F	22
08-Nov	2	92.0	F	P	11-Dec	4	72.6	F	33
08-Nov	2	90.0	F	P	22-Nov	6	73.9	F	14
08-Nov	2	95.0	F	P	11-Dec	4	71.7	F	33
08-Nov	2	92.0	F	P	05-Dec	6	75.5	F	27

Continued

Appendix 2. Spaghetti tag recoveries in the Harrison River, by application and recovery date and location, 1990.

Application sample					Recovery sample				
Date	Reach	NF length (cm)	Sex	Adipose fin	Date	Reach	POH length (cm)	Sex	Days out
Females initially identified as males: 1 0.8%							Mean days out:		22.6
Males initially identified as females: 5 35.7%							Maximum days out:		56
							Minimum days out:		1

POH and NF Regressions:

Males	POH =	0.74 NF + 5.84
	NF =	1.16 POH + 6.25
Females	POH =	0.77 NF + 2.80
	NF =	1.03 POH + 14.82

a. Incorrect sex identification during disk tag application.
b. Required ventilation assistance at release.

Appendix 3. Chinook carcass recoveries, by mark status and sex, in the Harrison River, 1990.

Date	Reach	Unmarked		Secondary mark only		Spaghetti tag and secondary mark		Total		Adipose absent	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
18-Oct	4	4	4	0	0	0	0	4	4	0	0
	6	5	7	0	0	0	0	5	7	0	0
	7	4	5	0	0	0	0	4	5	0	0
	8	0	1	0	0	0	0	0	1	0	0
23-Oct	4	15	16	0	0	0	0	15	16	0	0
	6	30	24	0	0	0	0	30	24	0	0
	7	15	19	0	0	1	0	16	19	0	0
24-Oct	7	33	33	0	0	0	0	33	33	0	0
	8	4	6	0	0	0	0	4	6	0	0
25-Oct	2	9	16	0	0	0	3 a	9	19 a	0	0
	3	8	4	0	0	0	0	8	4	0	0
	4	27	63	0	0	0	1	27	64	0	0
26-Oct	4	3	4	0	0	0	0	3	4	0	0
	6	34	30	0	0	0	1	34	31	0	1
	7	8	8	0	0	0	0	8	8	0	1
30-Oct	4	40	93	0	0	0	1	40	94	0	0
	5	18	40	0	0	0	1	18	41	0	0
01-Nov	2	18	38	0	1	0	0	18	39	0	0
	3	35	66	1	0	0	4	36	70	0	0
	5	12	6	0	0	0	2	12	8	0	0
02-Nov	5	40	85	1	0	1	1	42	86	0	0
	6	154	312	0	0	0	5	154	317	1	1
	7	23	29	0	0	0	1	23	30	0	1
	8	48	28	0	0	0	0	48	28	0	0
05-Nov	6	197	398	2	0	1	8	200	406	2	1
	7	67	117	0	0	0	3	67	120	0	0
06-Nov	7	78	103	0	0	0	5	78	108	0	1
07-Nov	2	31	38	0	0	0	1	31	39	0	0
	3	138	280	0	0	0	9	138	289	1	2
	4	10	48	0	0	0	1	10	49	0	0
08-Nov	4	95	185	0	0	1	3	96	188	3	2
19-Nov	8	98	126	0	0	2	7	100	133	1	3
20-Nov	7	168	188	3	1	1	10	172	199	1	2
	8	1	0	0	0	0	0	1	0	1	0
21-Nov	6	95	197	2	0	0	6	97	203	2	3 b
	7	2	8	1	0	0	0	3	8	0	0
22-Nov	4	99	19	0	0	0	5	99	24	1	1
	5	52	46	3	1	0	3	55	50	0	0
	6	41	173	1	0	1	6	43	179	0	2
27-Nov	4	88	111	0	0	0	1	88	112	1	0
	6	0	3	0	0	0	0	0	3	0	0
	7	0	1	0	0	0	0	0	1	0	0
	8	14	19	0	0	0	0	14	19	0	0
28-Nov	4	53	116	2	1	2	2	57	119	1	0
29-Nov	2	0	1	0	0	0	0	0	1	0	0
	4	11	17	0	0	0	3	11	20	0	0
	5	60	112	1	0	0	5	61	117	1	1
30-Nov	5	6	6	0	0	0	0	6	6	0	0

Appendix 3. Chinook carcass recoveries, by mark status and sex, in the Harrison River, 1990.

Date	Reach	Unmarked		Secondary mark only		Spaghetti tag and secondary mark		Total		Adipose absent	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
	6	24	29	0	0	0	0	24	29	2	0
	7	36	47	1	0	0	2	37	49	0	1 c
	8	35	34	1	0	1	0	37	34	2	0
03-Dec	4	9	14	1	0	0	1	10	15	0	0
	6	93	169	0	1	0	5	93	175	1	0
04-Dec	4	80	169	1	0	1	2	82	171	0	2
05-Dec	6	32	34	0	1	0	2	32	37	0	1
	7	8	3	0	0	0	0	8	3	0	0
	8	3	4	0	0	0	0	3	4	0	1
10-Dec	5	9	42	0	0	0	0	9	42	0	0
	6	32	95	0	0	0	0	32	95	0	1
11-Dec	4	59	179	1	1	0	8	60	188	0	2
12-Dec	4	35	86	0	0	0	1	35	87	0	0
13-Dec	3	23	69	0	0	0	1	23	70	0	1
	4	41	99	0	0	0	1	41	100	0	0
14-Dec	8	30	54	1	0	2	0	33	54	1	1
Total	2	58	93	0	1	0	4	58	98	0	0
	3	204	419	1	0	0	14	205	433	1	3
	4	669	1223	5	2	4	30	678	1255	6	7
	5	197	337	5	1	1	12	203	350	1	1
	6	737	1471	5	2	2	33	744	1506	8	10
	7	442	561	5	1	2	21	449	583	1	6
	8	233	272	2	0	5	7	240	279	5	5
Total		2540	4376	23	7	14	121	2577	4504	22	32

a. One required ventilation at release.
b. Includes 2 with questionable AFCs.
c. Questionable AFC.

Appendix 4. Spawning success of female chinook spawning ground recoveries, by mark status, in the Harrison River, 1990.

		Percent spawned			
		0%	50%	100%	Weighted mean
Spaghetti tag or secondary mark	Number	8	0	114	
	Percent	6.6%	0.0%	93.4%	93.4%
Unmarked	Number	9	0	151	
	Percent	5.6%	0.0%	94.4%	94.4%
Total	Number	17	0	265	
	Percent	6.0%	0.0%	94.0%	94.0%

Appendix 5. CWT spawning ground recoveries in the Harrison River, 1990.

CWT code	Release site	Brood year	CWTs Recovered		
			Male	Female	Total
2-37-54	Chehalis R.	1985	1	0	1
2-37-57	Chehalis R.	1985	1	0	1
2-40-52	Chehalis R.	1985	0	1	1
2-44-02	Chehalis R.	1986	2	1	3
2-44-03	Chehalis R.	1986	1	1	2
2-44-04	Chehalis R.	1986	4	3	7
2-44-05	Chehalis R.	1986	3	1	4
2-44-06	Chehalis R.	1986	6	3	9
2-44-07	Chehalis R.	1986	2	1	3
2-44-08	Chehalis R.	1986	0	2	2
2-44-09	Chehalis R.	1986	1	3	4
2-45-47	Chilliwack R	1986	1	1	2
2-47-38	Chehalis R.	1987	0	1	1
2-47-39	Chehalis R.	1987	1	0	1
2-57-47	Chilliwack R	1988	0	1	1
Total CWT carcasses			23	19	42
AFC carcasses with no CWT a			9	0	9
Total AFC carcasses			32	19	51

a. Excludes 3 with questionable AFCs.

Appendix 6. Incidence of CWT loss by carcass condition, eye status, and AFC condition in AFC chinook adult carcasses in the Harrison River, 1990.

Category	Condition	Number	CWT absent	CWT loss (%)
Carcass condition	Fresh	6	3	50.0%
	Moderately fresh	13	1	7.7%
	Moderately rotten	27	6	22.2%
	Rotten	8	2	25.0%
Eyes a	Present	5	2	40.0%
	Absent	45	10	22.2%
Adipose fin clip	Complete	45	6	13.3%
	Partial	6	3	50.0%
	Questionable	3	3	100.0%

a. [illegible]tion not recorded on 4 carcasses

Appendi[illegible] Mean lengths by age and sex for Harrison River chinook salmon, 1990.

Sample	Age	Sex	Sample Size	Percent	Length (cm) Mean	Standard deviation	Range
Application a,b	-	Male	1,355	37.5%	90.9	10.3	60.0 - 114.0
		Female	2,255	62.5%	87.7	5.7	61.0 - 108.0
		Total	3,610	-	88.9	7.9	60.0 - 114.0
Recovery c	2/1	Male	1	0.3%	50.4	-	-
		Female	0	0.0%	-	-	-
	3/1	Male	3	0.9%	62.4	12.8	47.6 - 69.8
		Female	5	1.5%	69.1	5.4	62.5 - 75.2
	4/1	Male	77	22.4%	74.0	5.5	61.0 - 88.9
		Female	251	73.0%	71.9	4.6	59.7 - 84.5
	5/1	Male	2	0.6%	83.5	4.5	80.3 - 86.7
		Female	5	1.5%	79.6	8.5	64.8 - 86.2
	Total	Male	83	24.1%	73.5	6.7	47.6 - 88.9
		Female	261	75.9%	72.0	4.8	59.7 - 86.2
		Total	344	-	72.3	5.4	47.6 - 88.9

a. Not adjusted for sex identification errors.
b. Nose-fork length.
c. Postorbital-hypural length.